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TENSILE AND COMPRESSIVE STRESS-STRAIN CURVES AND FLAT-END COLUMN STRENGTH FOR EXTRUDED MAGNESIUM ALLOY J-1

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TENSILE AND COMPRESSIVE STRESS-STRAIN CURVES AND FLAT-END COLUMN STRENGTH FOR EXTRUDED MAGNESIUM ALLOY J-1

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SUMMARY

Two stress-strain curves are presented for both tension and compression. In addition, the results of a number of flat-end column tests are presented.

The more apparent conclusions regarding extruded magnesium alloy J-1 are:

(1) It has a very low proportional limit in relation to the yield and ultimate strengths.

(2) It has a very low yield point for compression as compared with tension.

INTRODUCTION

For a number of years a portion of the Committee's theoretical research on structures has been directed toward a determination of the more efficient relative dimensions for a number of cross-sectional shapes commonly used for compression members of thin metal. In order to obtain an experimental verification of this theoretical work and also to demonstrate its practical value in design, it is planned to proportion a number of the more efficient cross-sectional shapes for test.

As there is a lack of general information regarding magnesium alloys, it was decided to conduct the experimental investigation with extruded magnesium alloy. On the recommendation of Mr. H. W. Schmidt of the Dow Chemical Company, the magnesium alloy J-1 was selected for the investigation. In order to obtain information regarding the properties of the material for the design of the cross-sectional shapes, tensile and compressive stress-strain curves were obtained. A number of flat-end column tests were also made in an effort to determine approximately the column curve for the material. The purpose of this report is to present the stress-strain curves and the results of the column tests made to date.

SPECIMENS

All specimens were cut from the angle extrusion of figure 1 at the locations shown. The nominal dimensions of the tensile and compressive specimens are given in figures 2, and 3, respectively. The nominal dimensions of the column specimens were the same as the compression specimens except for the length, which was varied. The dimensions of each specimen were measured with a micrometer reading to 0.0001 inch and these actual dimensions were used in all calculations.

APPARATUS AND METHOD OF TESTING

All tests were made in a hydraulically operated tension-compression testing machine having a 100,000-pound capacity and four dial ranges. The various accessories used are described under the type of test in which they are used.

Tension tests.- The tensile specimens were held by 10,000-pound capacity, self-alining Templin grips, and strain was measured by 2-inch Tuckerman optical strain gages mounted opposite each other on the specimen. Load and strain readings were taken at approximately equal strain increments until the proportional limit was passed; then readings were taken at equal load increments until the strains were too large. There being a decided strain creep after the material began to yield, the load was allowed to remain constant long enough for the strain to become essentially constant for each reading. All loads except ultimate loads were read on the 5000-pound range having 5-pound divisions. Ultimate loads were read on the 20,000-pound range having 20-pound divisions.

Compression tests.- The compression specimens were tested in a pack compression fixture of the type described in reference 1. Because the specimen was about 1/4 inch thick, it was unnecessary to make a pack of these specimens but merely to stabilize the specimen with the lateral supporting pins of the pack compression fixture. Tuckerman optical strain gages of 1-inch length were mounted on opposite sides of the specimen.

Figure 4 shows one of the compression specimens under a stress of 38,000 pounds per square inch after the strain gages have been removed. At the start of the test the lateral supporting pins were horizontal; whereas, under the stress of 38,000 pounds per square inch, the top pins were considerably inclined (fig. 4) as a result of the strain in the specimen. Figure 5 shows the specimen of figure 4 after failure.

Column tests.- The column specimens were tested using one of two fixtures for alining the upper loading head with the specimen. The first fixture, shown in figure 6, is essentially the same as the pack compression unit without the side supports. Uniform bearing was obtained by means of a plaster-of-paris shim, which appears in figure 6 as a light horizontal line above the specimen. The shim was 0.02 to 0.03 inch thick, all excess plaster being squeezed out by application of a small initial load.

Figure 7 shows the second fixture used in the column tests. The device shown is a spherically seated self-alining compression head; it was properly alined by tapping because the friction in the seat was too great for the specimen to overcome. All but eight of the column specimens were tested with this fixture because no appreciable difference in test results was noted for the two fixtures.

RESULTS

Two stress-strain curves were determined for both tension and compression. These curves are given in figures 8 to 11, inclusive. The proportional limit was determined for each stress-strain curve according to the methods described in reference 2. For comparison, all stress-strain curves are plotted on the same chart in figure 12.

In table I are given the values of Young's modulus, ultimate strength, yield strength, and proportional limit as determined from the tensile and the compressive specimens. In addition, the percentage elongation in 2 inches is given for the tensile specimens.

The results of the column tests are presented in figure 13. The dimensions of the column specimens were selected before the stress-strain curves had been determined. Consequently, the dimensions of the column specimens, which were selected on the basis of a much higher yield point, do not cover a sufficient range of slenderness ratio to establish the column curve near the Euler range.

CONCLUSIONS

The more apparent conclusions regarding the properties of extruded magnesium alloy J-1, as drawn from table I and figures 8 to 12, are:

1. It has a very low proportional limit in relation to the yield and ultimate strengths.

2. It has a very low yield point for compression as compared with tension.

The dimensions of the column specimens, which were selected on the basis of a much higher yield point, do not cover a sufficient range of slenderness ratio to establish the column curve near the Euler range.

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REFERENCES

1. Aitchison, C. S., and Tuckerman, L. B.: The "Pack" Method for Compressive Tests of Thin Specimens of Materials Used in Thin-Wall Structures. Rep. No. 649, NACA, 1939.

2. Templin, R. L.: The Determination and Significance of the Proportional Limit in the Testing of Metals. A.S.T.M. Proc., vol. XXIX, pt. II, 1929. Discussion of paper by L. B. Tuckerman, pp. 538-546.

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TABLE I.- SUMMARY OF TENSILE AND COMPRESSIVE

TESTS OF EXTRUDED MAGNESIUM ALLOY J-1

Specimen	Young's modulus (lb/sq in.)	Ultimate strength (lb/sq in.)	Yield strength (lb/sq in.)	Proportional limit (lb/sq in.)	Elongation in 2 inches (percent)
Tension					
1	6.211×10^6	43,920	27,100	[a]11,700	21
2	6.329	44,370	27,700	[a]10,500	24
Compression					
1	6.467	59,700	17,500	[b]10,940	-----------
2	6.376	62,500	17,250	[b]12,400	-----------

[a]Proportional limit based on accuracy of measurement of load and strain equivalent to $\pm 10 \times 10^{-6}$ in./in. strain.

[b]Proportional limit based on accuracy of measurement of load and strain equivalent to $\pm 8 \times 10^{-6}$ in./in. strain

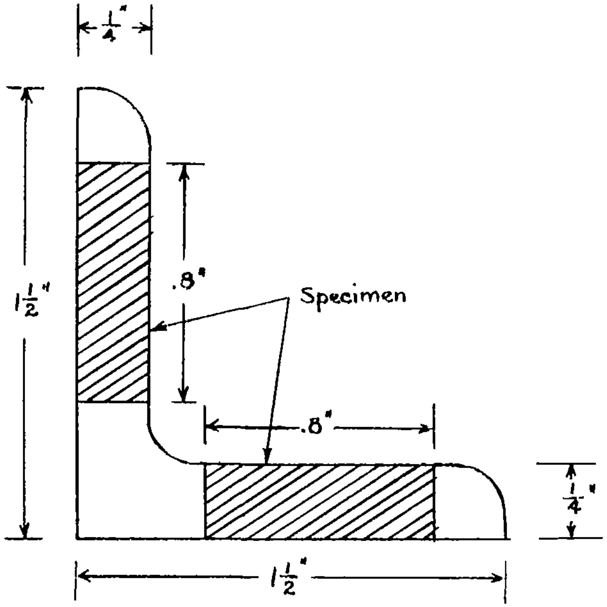

Figure 1.- Extruded J-1 magnesium alloy angle from which specimens were prepared.

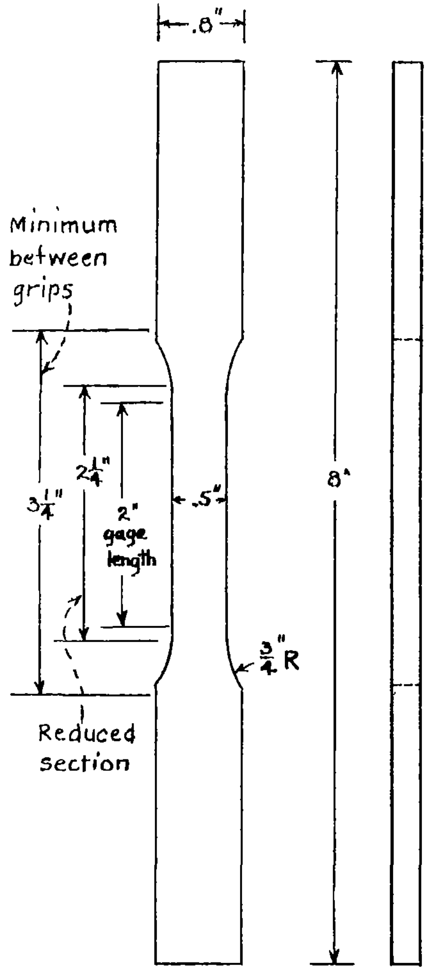

Figure 2.- Nominal dimensions of tensile specimen.

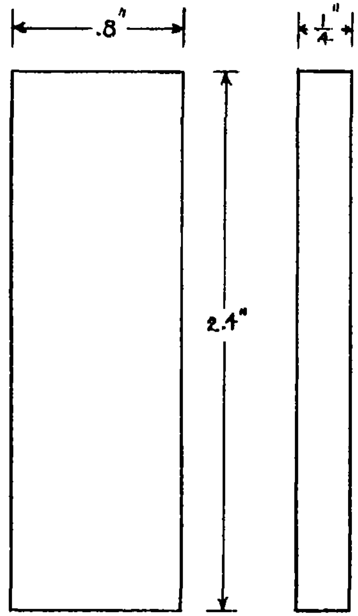

Figure 3.- Nominal dimensions of compression specimen.

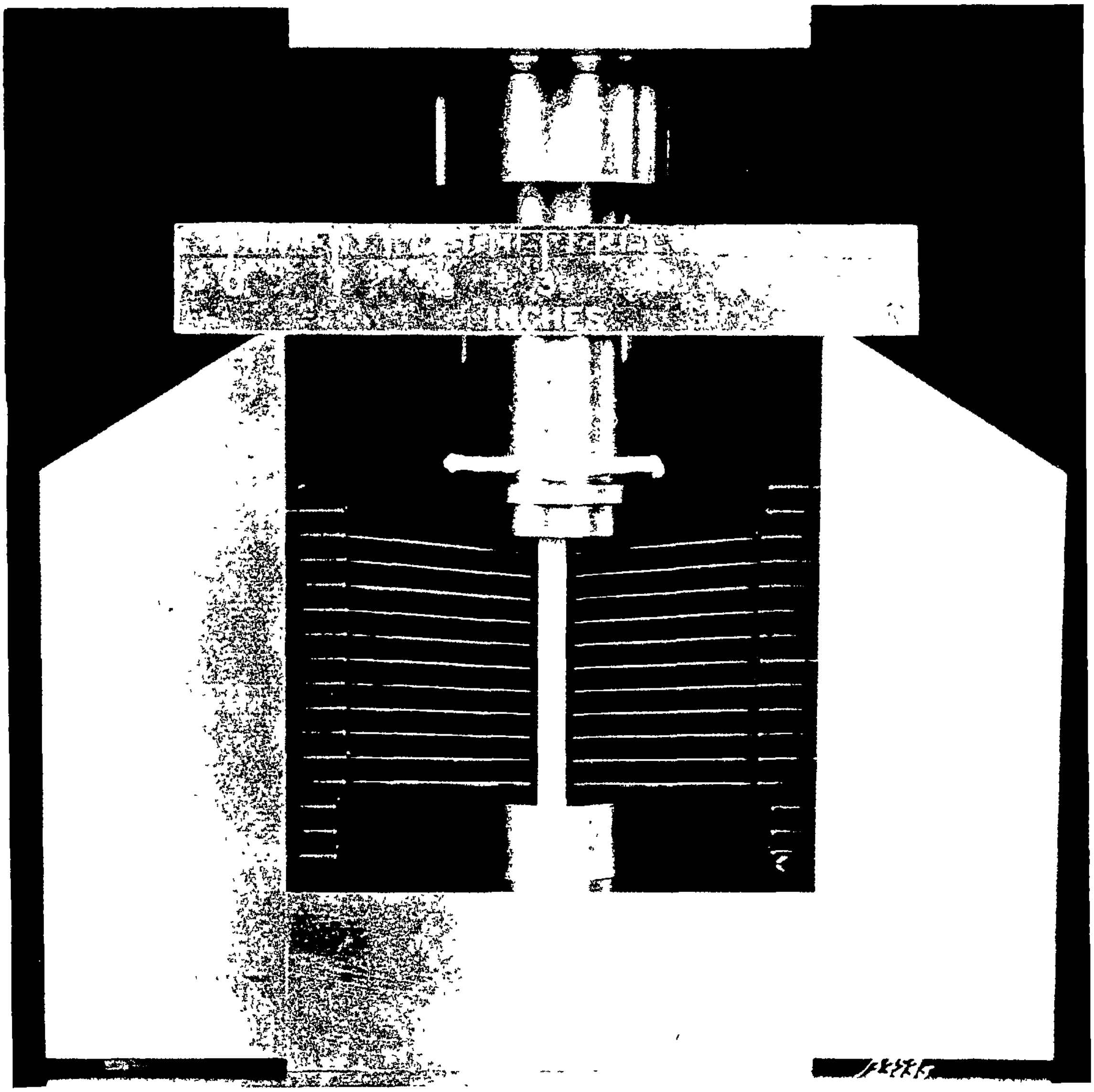

Figure 4.- Compression specimen of magnesium alloy J-1 under a stress of 38,000 pounds per square inch in pack compression fixture.

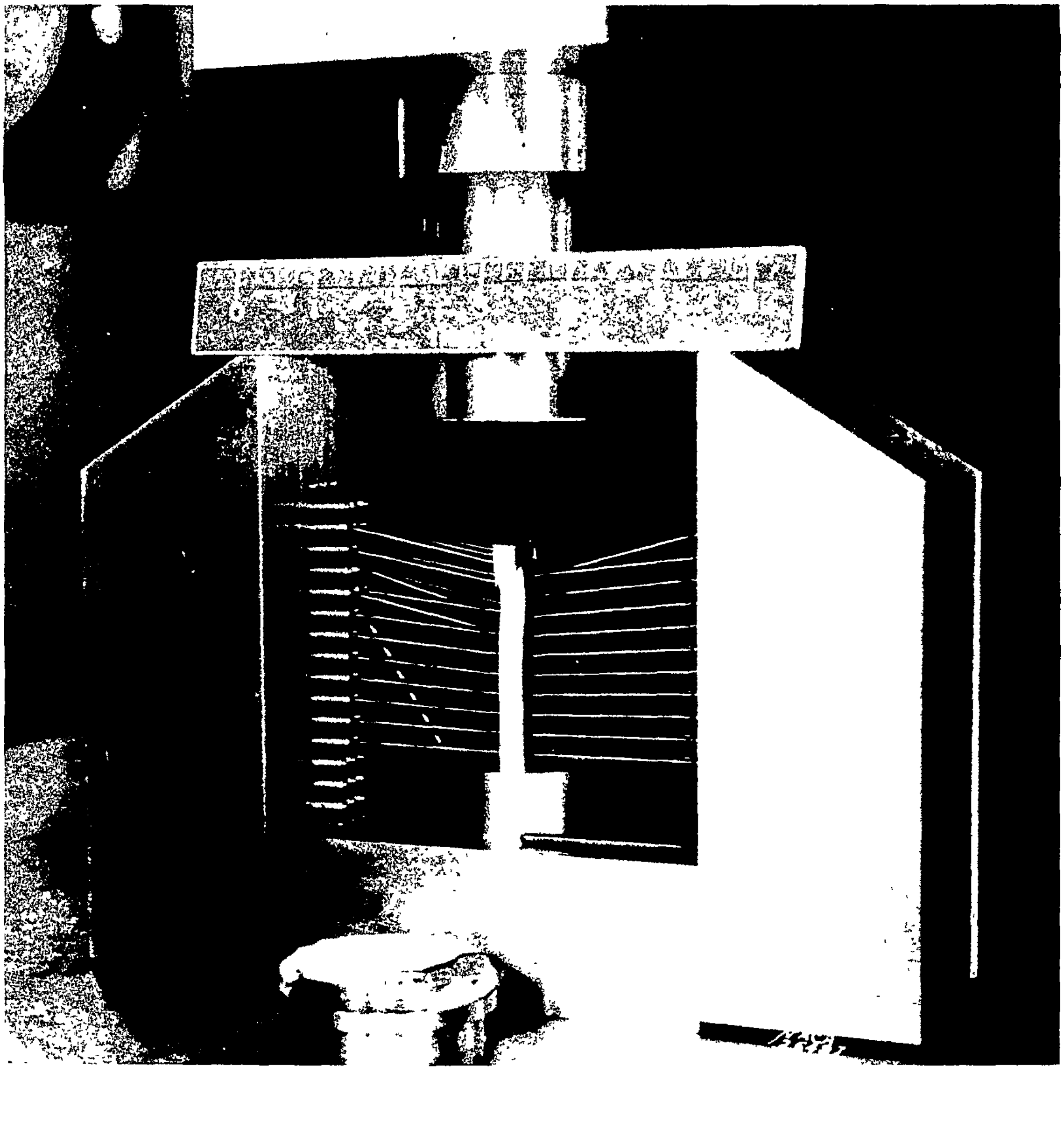

Figure 5.- Specimen of figure 4 after failure.

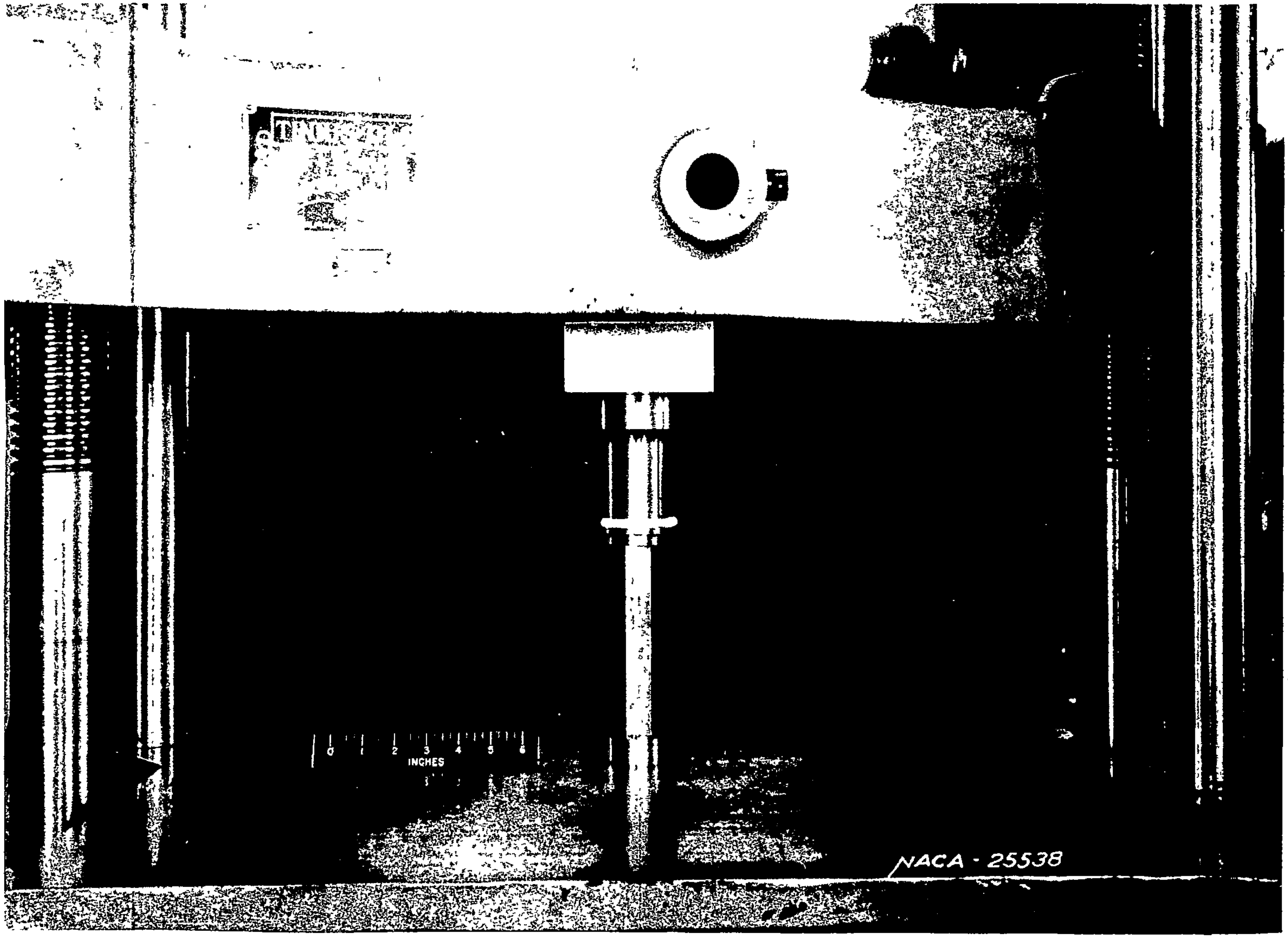

Figure 6.- Fixture used in flat-end column tests where uniform bearing was obtained by means of a plaster of paris shim.

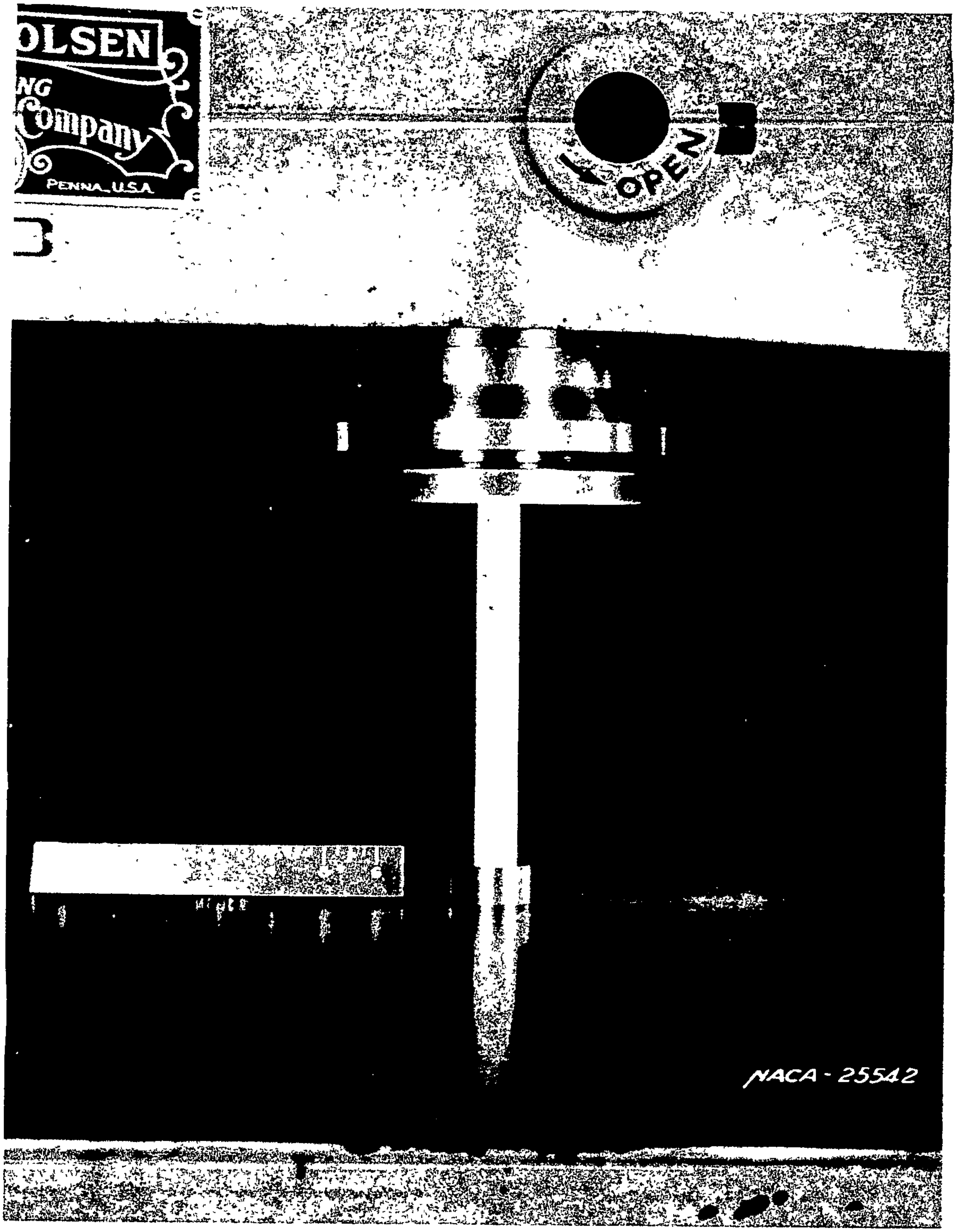

Figure 7.– Fixture used in flat-end column tests where uniform bearing was obtained by means of a spherically seated head.

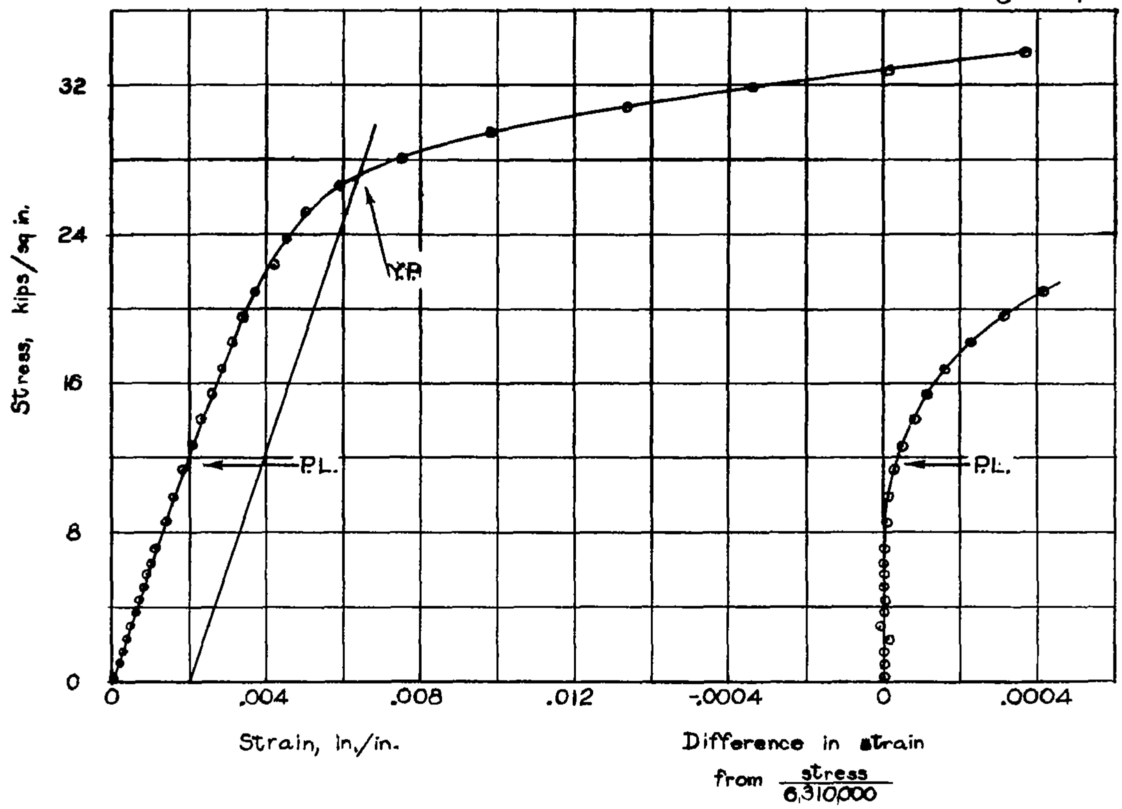

Figure 8. - Tensile stress-strain curve and difference curve for tensile specimen 1.

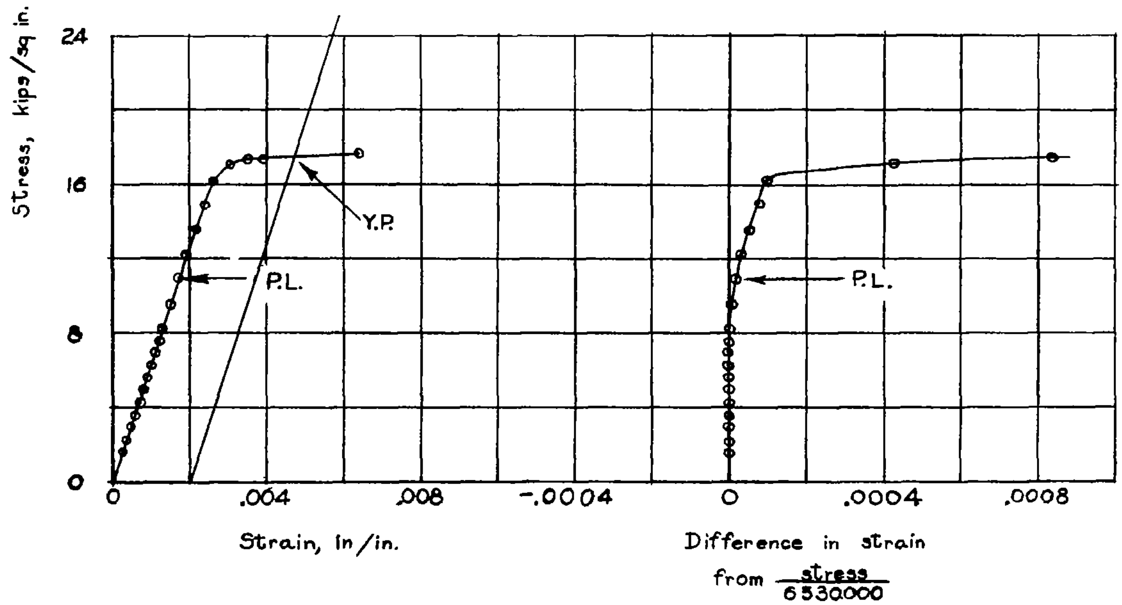

Figure 10. - Compression stress-strain curve and difference curve for compression specimen 1.

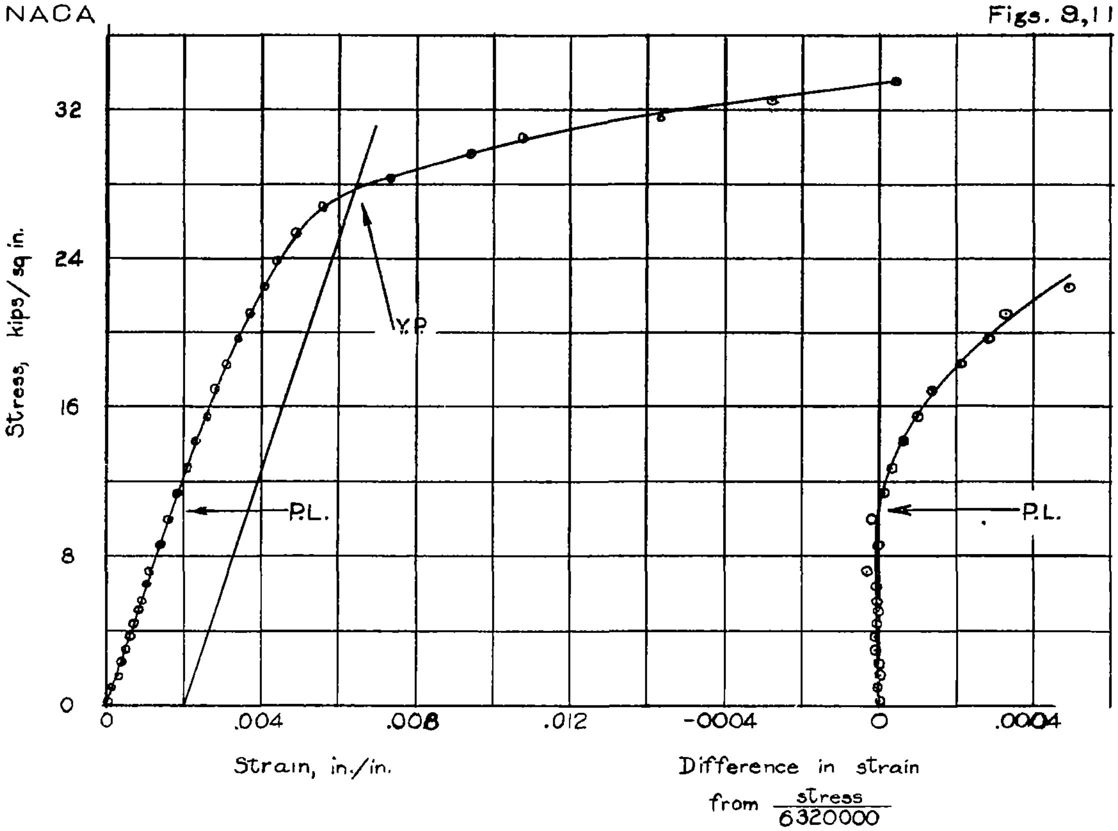

Figure 9. - Tensile stress-strain curve and difference curve for tensile specimen 2.

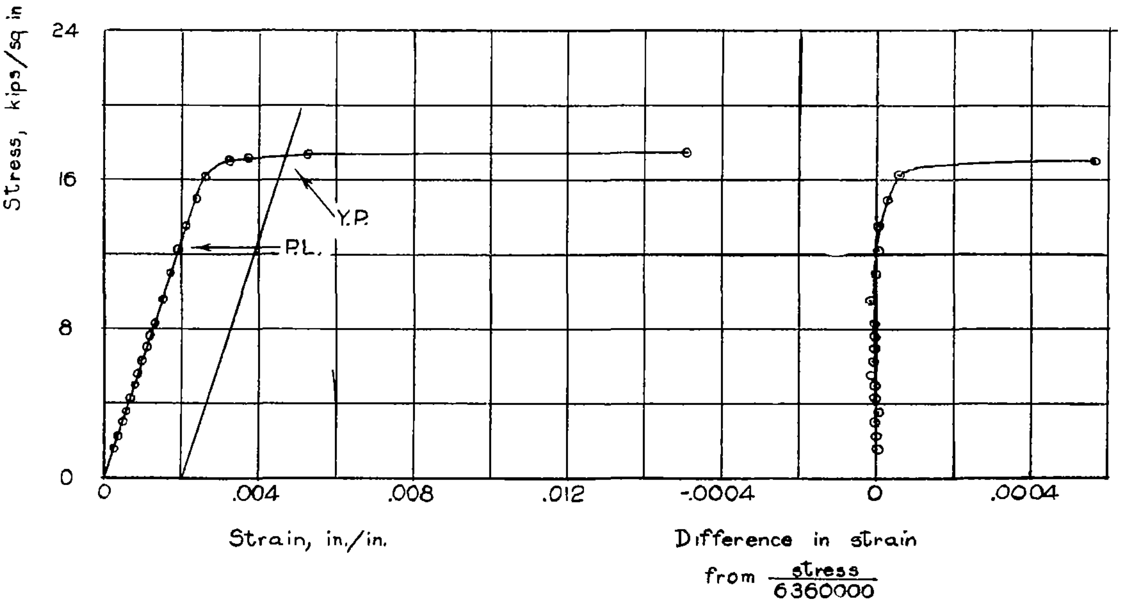

Figure 11. - Compression stress-strain curve and difference curve for compression specimen 2.

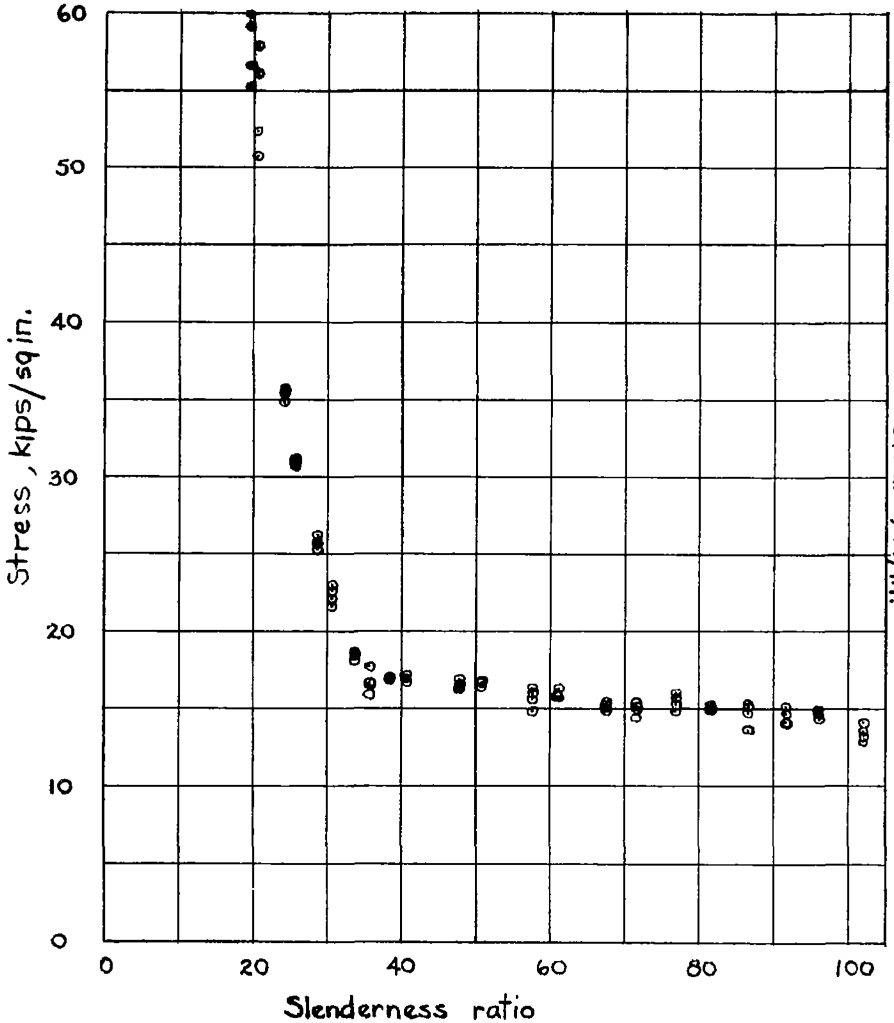

Figure 13.- Flat-end column test data.

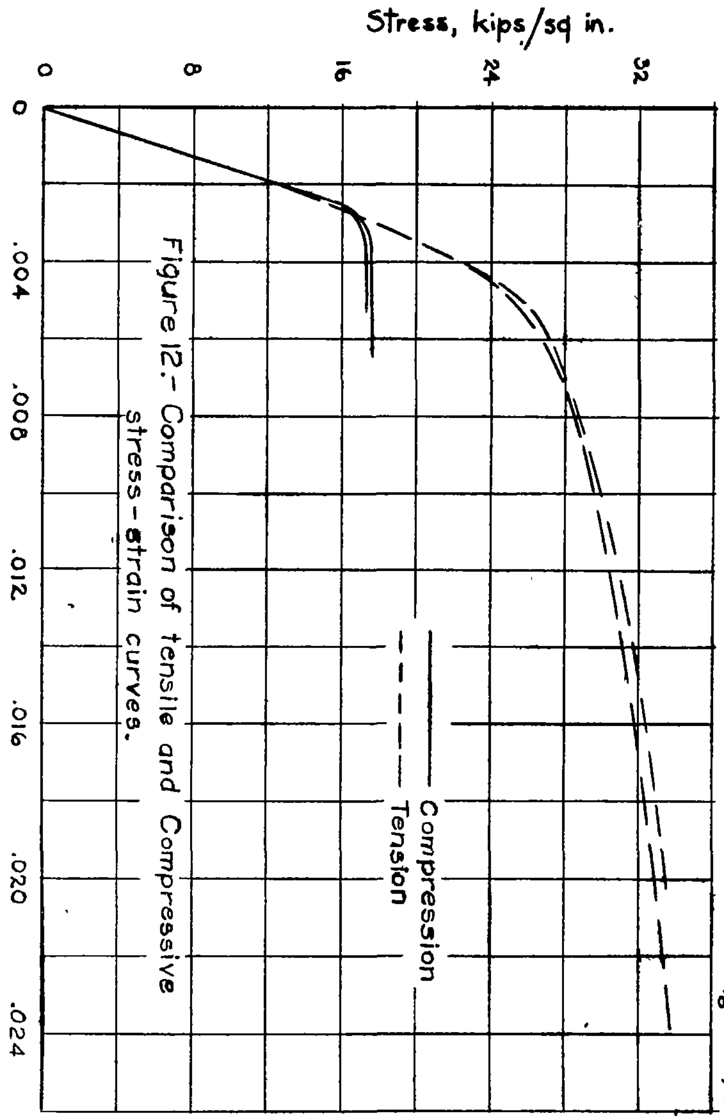

Figure 12.- Comparison of tensile and Compressive stress-strain curves.